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TELANGIOPSIS GEN. NOV., AN UPPER MISSISSIPPIAN POLLEN ORGAN FROM ARKANSAS

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ABSTRACT

Telangiopsis arkansanum is described from compressed synangiate pollen organs borne terminally on a monopodially branched system of slender axes. The specimens occur in a fine-grained shale unit of the Wedington sandstone (Chester series). Individual synangia contain five or six sporangia, measure approximately 1.0 mm long and 0.8 mm wide, and contain radial trilete spores ranging from 47 to 54 μ in diameter. A discussion of the genus *Telangium*, to which similar remains would have previously been assigned, is presented. The generic name *Telangium* is retained for the petrified species *T. scotti* and *T. pygmaeum*, while the generic name *Telangiopsis* is proposed to include nonpetrifaction specimens previously assigned to the genus.

Introduction

The present paper is the first of a series describing a nonpetrifaction flora of cast, mold, compression, and impression plant fossils from upper Mississippian (Chester series) strata of Arkansas. Much of the material, including that described in this account, comes from a new locality in the vicinity of the Lincoln city reservoir, Washington County, Arkansas. Thus far, this locality has yielded an abundance of plant remains whose general level of preservation and extensiveness exceeds that of any material that has previously been known from this horizon, either in Arkansas or elsewhere in the midcontinental United States. The plant-bearing bed consists of an extensive lens of gray shale reaching a maximum thickness of about 65 ft and extending for approximately $\frac{1}{4}$ mile where exposed. This shale unit occurs within the Wedington sandstone, serving to divide the sandstone into an upper and lower unit where the shale is present. To date, no formal name has been applied to this shale; however, it has been informally referred to by SARTIN (1966) as the Wedington shale.

Various components of this flora will be described in subsequent papers; however, it should be noted that the flora comes from the so-called zone 3 of *Fryopsis* spp. and *Sphenopteridium* spp., using the system of floral zonation applied by READ and MAMAY (1964). Previous work on the flora of the Wedington sandtone of Arkansas by WHITE (1937*a*) included very fragmentary remains both from sandstone and from very restricted shale lenses and bands within the sandstone unit. Compression-impression floras representing Late Mississippian time are relatively rare in North America. The few publications dealing with such material include those of WHITE on the Wedington sandstone (1937*a*) and on the Stanley shale and Jackfork sandstone of Oklahoma (1937*b*), the exact ages of which are uncertain. A florule from Utah has been described by ARNOLD and SADLICK

(1962), and a flora consisting mostly of structureless molds and casts has been described from southern Illinois by LACEY and EGGERT (1964). Most recently, JENNINGS (1970) has demonstrated the presence of an extensive flora, exhibiting a variety of preservational modes, from the majority of the formations included in the Chester series of Illinois.

Comments on floral composition of the Arkansas and Oklahoma floras have been made by MAMAY (in MISER and HENDRICKS 1960) and READ and MAMAY (1964), who have suggested that these floras, along with the very incompletely known floras of the Bluestone formation (West Virginia) and Parkwood formation (Alabama), may ultimately be shown either to represent a late subzone of zone 3, mentioned above, or to have a sufficiently distinct flora to merit a separate zone. In the latter instance, such a flora would represent the youngest Mississippian plants known, occupying a position between the more characteristic Chester series flora (zone 3) and the oldest Pennsylvanian floras (zone 4) of North America.

The intent of the present paper is to describe a new type of pollen organ resembling some of the material placed in the genus *Telangium* Benson (1904). Remains of the *Telangium* type are rare in North America, and little indisputable information is available concerning their parent plants, although BENSON (1904) and subsequent workers have strongly suggested that they were produced by monostelic pteridosperms such as *Lyginopteris* and possibly other members of the Lyginopteridaceae. From its inception, *Telangium* has been a repository for extremely flattened compressions, three-dimensional mold and cast systems, partial petrifactions found in ironstone nodules, and petrifactions of coal ball origin. A discussion of the usage of the generic name *Telangium* is presented in the final section of this paper; however, to facilitate description of our material, we are proposing a new generic name for compression material of the type described here. *Telangium scotti*, the first species listed after the diagnosis portion of BENSON's paper (1904), we are regarding as the type species of the genus. At the present time this petrifaction species and *T. pygmaeum* Graham (1934) are the only taxa assigned to the genus. Material of a compressed nature, such as that from Arkansas, is being placed in a new genus called *Telangiopsis*, to which all species of *Telangium* listed below are to be transferred.

Systematics

Telangiopsis Eggert and Taylor, Form Gen. Nov.

GENERIC DIAGNOSIS.—*Telangiopsis* Eggert and Taylor Form Gen. Nov. Synangiate organs with variable number of sporangia organized into stalked, radial clusters, borne terminally on either dichotomously or monopodially branching axes lacking planated foliar structures. Sporangia fused at base, distally free. Type species: *Telangiopsis arkansanum* Eggert and Taylor.

SPECIFIC DIAGNOSIS.—*Telangiopsis arkansanum* Eggert and Taylor, n. sp. Monopodially branching system of axes bearing terminal synangia with 5–6 sporangia. Individual synangia measuring approximately 1.0 mm long and 0.8 mm wide. Individual sporangia with acuminate tips and producing radial, trilete spores 47–54 μ in diameter characterized by granulose-levigate ornamentation. Holotype: specimen no. 1325*a* and *b* (part and counterpart), Paleobotanical Collections, Department of Biological Sciences, University of Illinois at Chicago Circle, Chicago, Illinois; figure 1 in this paper.

Paratypes: Specimen no. 1326 (fig. 2) and no. 1333 (figs. 3–5) in the above collections.

Collection locality: Lake Lincoln Dam site, SW $\frac{1}{4}$ sec. 5, T 15 N, R 32 W, Starr Hill Quadrangle, Washington County, Arkansas.

Stratigraphy: Shale unit ("Wedington shale") within Wedington sandstone, Fayetteville formation, Chester series.

Age: Upper Mississippian.

Additional forms to be assigned to *Telangiopsis* are:

1904: *Telangium affine* (Lindley et Hutton) Benson, Ann. Bot. **18**:164, pl. 11, fig. 12.

1904: *Telangium bifidum* (Lindley et Hutton) Benson, Ann. Bot. **18**:164 (synangia only).

1911: *Telangium nutans* Carpentier, Rev. Gen. Bot. **23**:452, pl. 15, figs. 1–6.

1914: *Telangium asteroides* (Lesquereux) Kidston, Roy. Soc. (Edinburgh), Trans. **50**:96; auct. non Kidston, 1887, Roy. Soc. (Edinburgh), Trans. **33**:148.

1914: *Telangium ingeborgense* Nathorst, Zur Foss. Flora der Polarländer **1**:21, pl. 15, figs. 33 and 34.

1914: *Telangium millerense* Nathorst, Zur Foss. Flora Polarländer **1**(no. 4):22, pl. 15, figs. 35–42.

1924: *Telangium digitatum* Kidston, Geol. Surv. Great Britain, Mem. **2** (no. 5):461, pl. 112, figs. 1 and 1*a*.

1960: *Telangium bretonensis* Bell, Nova Scotia Mem. 314, p. 39, pl. 15, figs. 4 and 5; pl. 16, figs. 1–5, 8; pl. 17, figs. 1 and 4 (synangia only).

The following have been assigned to *Telangium* without specific names by the authors indicated:

1962: *Telangium* species Lele et Walton, Mus. Natur. Hist. Geol. Bull. **7**(no. 4):143, pl. 21, figs. 23–26. Arber et Goode, 1915, Cambridge Phil. Soc. Proc. **18**:99, pl. 4, figs. 1–7, 10, 11. Kidston, 1924, Geol. Surv. Great Britain, Mem. **2**(no. 5):464. Carpentier, 1931, Soc. Sci. Natur. Ouest, France, Bull. **1**:4, pl. 1, fig. 3. Lutz, 1933, Palaeontographica **78B**:148, pl. 19, figs. 14–16. Halle, 1937, Compt. Rend. 2d Congr. Strat. Carb. Heerlen

1:230, pl. 6, figs. 12 and 13. Thomas, 1938, Compt. Rend. 2d Congr. Strat. Carb. Heerlen, figs. 1*B–D*. Stockmans et Willière, 1953, Ass. Étud. Strat. Houilleres, **13**:338, figs. 8 and 8*a*. Bell, 1960, Nova Scotia Mem. 314, pl. 17, fig. 2.

The following have been questionably assigned to *Telangium* by the authors indicated:

? *Telangium* species Walton, 1928, Quart. J. G.S. **84**:410. White, 1937, U.S. Geol. Surv. Prof. Paper 186B, p. 24, pl. 5, fig. 2. *Telangium? acuminatum* (Dawson) Stockmans et Mathieu, 1939, Patrimoine Mus. Roy. Hist. Natur. Belg., p. 126, pl. 2, fig. 7.

A complete listing of literature citations may be found in JONGMANS and DIJKSTRA (1965), along with certain forms which we have chosen to exclude from the genus.

Description

Of the several specimens available for study, the most extensive specimen (fig. 1) best illustrates the general features of the fertile region. A basalmost axis (fig. 1, *A*) bears primary laterals alternately approximately 1.0 cm apart. These primary laterals, which are oriented almost at right angles to the basal axis, are approximately 0.8 mm wide in comparison with the basal axis, which measures 2.0 mm. One of the primary laterals is seen in figure 1, *B*. In this instance the primary is relatively complete and shows alternate secondary branching systems. A portion of an additional primary, bearing ramifying secondary systems, is illustrated in figure 2. All of the specimens examined illustrate that the specific number of branchings in the systems borne by the primaries varies, with larger numbers of branchings in the most basal systems and progressively fewer branchings present as one moves distally along the primary. Each of these lateral systems has a somewhat broader major branch, with narrower lateral branching systems borne alternately along its length. In a superficial manner, these lateral systems correspond to the venation system present in a typical laminar frond structure such as a pinna or pinnule. The progressive decrease in the number of branchings of the systems distally corresponds to the superficial venation pattern in planated foliar areas of a typical frond. Topographically, the much branched lateral systems borne by the primaries are equivalent to various orders of pinnae and possibly pinnules as these terms are used when planated foliar regions are present; however, application of such terms to the present material would only serve to add confusing terminology. As is apparent in several of the figures, each of the ultimate branchlets is terminated by a single synangium. Technically, this ultimate branchlet forms the synangial stalk, although it does not appear to be modified in any manner.

Synangia may be composed of either five or six sporangia. Those with five predominate, but several examples in which six are present (fig. 4, arrow) have been observed. When viewed from the base, the sporangia are seen to be radially disposed and free laterally (fig. 5, arrow). Lateral views like those in figures 2 and 3 illustrate the degree of separation present among sporangia of each cluster. Figure 3 illustrates that the sporangia are attached to each other only at their extreme bases. This figure also shows that the sporangial cavities were separate throughout the lengths of the sporangia, with a thin separating layer of tissue present between adjacent sporangia. In cases where the synangium was broken in a median longitudinal plane by the splitting of the matrix (fig. 3, arrow), it can be seen that the central hollow which was surrounded by sporangia was conical and extended to the very base of the synangium. Transversely, the individual sporangia are roundly triangular in outline (fig. 4), while in longitudinal section, they are approximately three times as long as they are broad, being slightly curved toward the synangium center. Distally, each sporangium is pointed.

In instances where the matrix separated along the sporangial walls (fig. 5, upper synangium), some indication of the nature of the sporangial wall cells can be observed. Individual sporangial cells are axially elongate, have curved end walls, and are not aligned in either vertical or horizontal rows. The open configuration of the synangia suggests that the pollen organs were relatively mature and had no doubt reached anthesis prior to preservation. This is also borne out by the small number of spores present in any of the sporangia. However, no consistent feature could be found to suggest the manner of sporangial dehiscence. Sporangial tips appear to be intact, and it seems likely that the sporangia opened longitudinally along the surface, directed toward the center of the synangium.

Spores were recovered by scraping sporangial fragments from the matrix and treating these as maceration preparations. No entire spore masses were recovered. Spores of *Telangiopsis arkansanum* are radial and trilete, and range from 47 to 54 μ in diameter. The wall is thin and often characterized by numerous arcuate folds (fig. 6) resulting from oblique compression. Ornamentation is granulose to levigate, with the majority of the specimens showing some form of degradation of the exine (fig. 8). Features of the trilete are illustrated in figure 7, whereas figure 8 shows the distal surface of a typical spore. Spores of *T. arkansanum* conform most closely to the dispersed spore genus *Punctatisporites* (Ibrahim) Potonié and

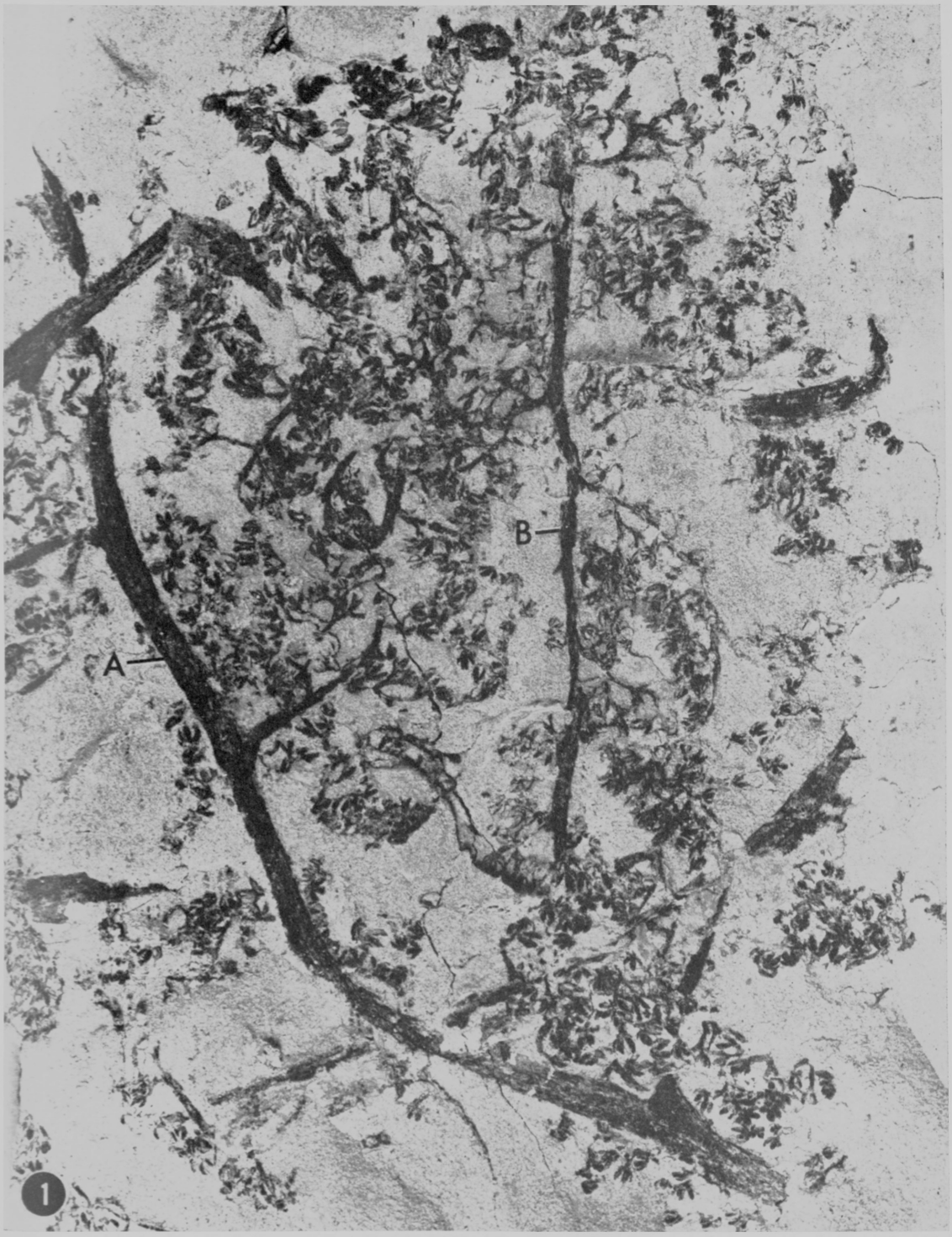
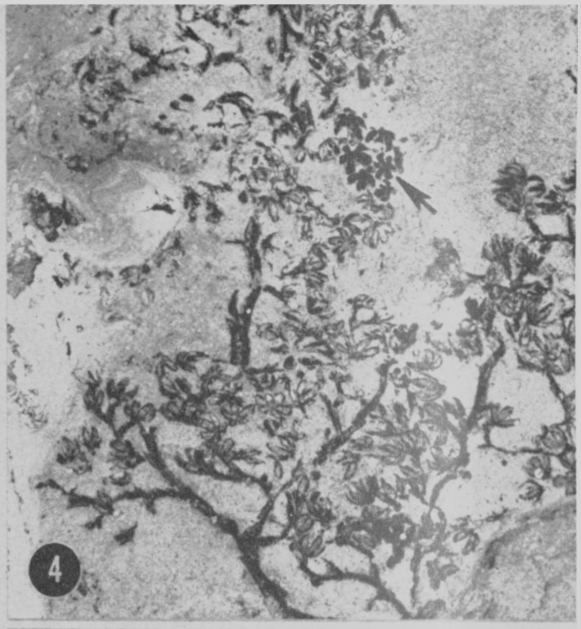
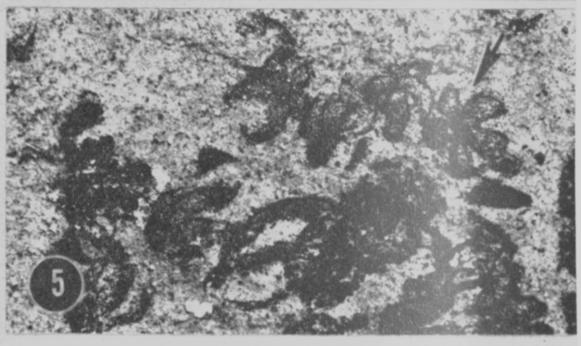
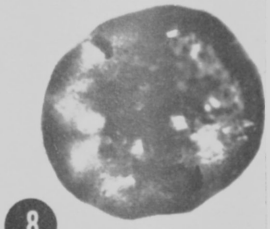


FIG. 1.—*Telangiopsis arkansanum* gen. et sp. nov.; holotype specimen illustrating general features of the fertile region. UICC 1325*a* (part); × 3.2.







FIGS. 2–8.—*Telangiopsis arkansanum* gen. et sp. nov. Fig. 2, Primary lateral and attached distal portions showing features of attachment and distribution of synangia. UICC 1326*a* (part); × 5. Fig. 3, Portion of fertile region showing sporangial wall and conical hollow central region. UICC 1326*a* (part); × 11; photographed under xylene. Fig. 4, Portion of fertile region illustrating variability in sporangial number. UICC 1333; × 4. Fig. 5, Detail of several synangia showing synangial base and basal fusion of sporangia. UICC 1325*a* (part); × 11; photographed under xylene. Fig. 6, Spore showing characteristic arcuate folding of wall. Maceration no. 4; × 600. Fig. 7, Spore showing proximal surface and details of trilete. Maceration no. 6; × 600. Fig. 8, Distal view of spore showing granulose surface ornamentation. Maceration no. 4; × 600.

Kremp (Potonié and Kremp 1955). The generally poor preservation of our spores precludes identification to the species level.

Discussion

From the initial use of the generic name by Benson (1904) to the present day, the name *Telangium* has been applied to a variety of plant remains occurring in various states of preservation. Several workers, including Walton (1931), have suggested that the material in question should be referred to several genera. Approximately 17 types are listed in Jongmans and Dijkstra (1965), several of which are either reported as being assigned to the genus without species names or are listed as *Telangium* species. It is not our purpose to review the features of all of these forms in detail. However, some pertinent remarks seem in order.

Our basis of understanding of the petrified material assigned to *Telangium* rests upon the description of *T. scotti* (Benson 1904), from Upper Carboniferous coal balls of Great Britain. This species is also listed as occurring in approximately contemporaneous strata of the Netherlands (Westphalian A of Limburg) and Germany (Koopmans 1928). However, no published descriptions of the Continental material are available, and illustrations of some specimens by Koopmans do not convincingly demonstrate that this is the same as Benson's British coal ball specimens.

As described by Benson, *T. scotti* is a synangiate organ approximately 4.5–5.5 mm long and 3.0 mm in diameter consisting of eight sporangia arranged in two rows, fused laterally and along their inner faces, to form an organ which is elliptical in transverse section. The sporangia appear to be fused for at least half of their length and are free distally. However, Benson's illustrations may be interpreted in a variety of ways on this point. The sporangia apparently had acuminate tips and opened in the median vertical plane along their inner faces at least to the level where they were fused. The sporangial walls consisted of an outer large-celled epidermis and a deeper tissue constructed of thin-walled cells, some of which show scalariform wall thickenings. Near the base of the synangium, a so-called lacunar tissue was present. The sporangial walls show progressively more layers of cells toward the base of the synangium, where the fused sporangia form an almost solidly parenchymatous tissue with a central vascular strand. Comparison of this area with a much reduced pinnule has been made, especially by Scott (1909, 1923) and Kidston (1906), both of whom have used this feature to suggest either close comparability or identity between *T. scotti* and the genus *Crossotheca*. Benson's description of *T. scotti* includes a description of elliptical spores 50–60 μ long and up to 40 μ in maximum width. It is of interest to note that the exine ornamentation is described as a series of anastomosing ridges that encircle the body of the spore, since this type of ornamentation is present in our material from Arkansas.

Some additional petrifaction material briefly described by Scott (1909) led him to conclude that synangia of the *T. scotti* type were borne on a "flat disc or lamina" as in *Crossotheca*, while in a later work (Scott 1923) an illustration of a presumed *Telangium* consisting of a pair of bilocular sporangia is shown and cited as offering proof of the identity of *Telangium* and *Crossotheca*. Although the histology of the sporangial walls shown in this figure is essentially like that of *T. scotti*, so little is now known of the material described by Scott that the matter of its comparability with *Telangium* is open to serious doubt. No illustrative proof of the evidence for attachment of organs of the *T. scotti* type to foliar structures such as reduced pinnules has ever been presented, and Kidston (1924) points out that no evidence of such a feature is present in the compression types of *Telangium* described either by Benson, at the time of the description of *T. scotti*, or by subsequent workers. We regard *T. scotti*, the first species listed after the diagnosis portion of Benson's original description of the genus, as being the species upon which the generic concept of *Telangium* is to be based. As we have discussed above, other petrifaction specimens are only doubtfully included in *Telangium*. A form from North American coal balls, *T. pygmaeum* (Graham 1934) also falls within this doubtful category. Features of *T. pygmaeum* lead us to believe that this form has little in common with *T. scotti* and probably does not represent the same genus. A reinvestigation of the original material is necessary before any formal change in the nomenclature of this species is carried out. It is, therefore, most convenient to retain *T. pygmaeum* in the genus *Telangium* for the present.

Fructifications of the general type represented by *Telangium* and *Telangiopsis* are rare in North America. The only previous report of pollen organs of this type from the Fayetteville formation is that of White (1937*a*), which consisted of a description and figures of a single, problematical, and apparently indeterminable detached object. Described as *Telangium*? sp. by White, this specimen does not show the characteristic features assigned to comparably preserved material described here, or to any other compression species described under the generic name *Telangium* for which the features of the synangia have been clearly depicted.

Additional material from North America, described under the generic name *Telangium*, is that

from the Horton group of Nova Scotia (BELL 1960). *Telangium bretonensis* Bell is the name applied to both foliage and unattached objects presumed to be synangia made up of microsporangia. The individual synangia are reported as having 12–15 sporangia borne along the margin of a disklike structure approximately 4.0 mm long. The features of the synangia are obscure in the illustrations. If the disklike structure and marginal attachment of the sporangia are borne out by subsequent work, this material would be more comparable to *Crossotheca* than to pollen organs of the general type represented by *Telangium or Telangiopsis*. The sporangia appear to be unilocular in the material from Nova Scotia, and in this respect it would resemble *Telangiopsis* rather than *Crossotheca*, which presumably had bilocular sporangia.

Specimens originally described from Middle Pennsylvanian strata of Illinois under the names *Staphylopteris asteroides* and *Sorocladus asteroides* by LESQUEREUX (1870, 1880) and subsequently transferred to *Telangium* by KIDSTON (1914) bore structures representing either cupules or synangia in a single row along laterals of a monopodially branched system. The portion of the frond represented in the material lacks any planated foliar regions. Approximately six structures are fused basally in each cluster whose overall appearance is like that of a radially symmetrical pollen organ of the *Telangiopsis* type. Unfortunately, the exact nature of these parts has never been determined.

Compressed specimens of *Telangiopsis* have recently been discovered and illustrated by JENNINGS (1970) from strata of the Chester series in southern Illinois.

We have already mentioned *Telangium pygmaeum*, a petrified form from Illinois originally described by GRAHAM (1934). This species probably represents some sort of marattialean synangiate fructification of either the *Scolecopteris*-type or some similar genus.

Of the various species of *Telangiopsis*, based upon compression fossils, relatively few may be compared adequately with *T. arkansanum*, primarily because of lack of information. The more adequately characterized species include *T. bifidum*, L. & H. sp., *T. affine*, L. & H. sp., and *T. nutans*, Carpentier sp. Individual synangia of *T. bifidum* have a relatively large number of sporangia (approximately 25) and occur at the terminations of ultimate ramifications of equal dichotomous branchings present in the fertile regions. The sporangia are relatively large in this species, approximately 6.5–6.7 mm long and 3.75–4.0 mm broad as reported by KIDSTON (1887). *Telangiopsis affine* has similar terminal synangia, each of which possess six sporangia. The individual synangia of this species are 2.5–3.5 mm long and 2.75–3.0 mm in breadth (BENSON 1904). Spores of these two species are known and have been described as circular-subcircular in outline. In *T. affine* the spores measure approximately 52 μ in diameter and the arms of the trilete are described as being short, while ornamentation of the wall is levigate. Spores of *T. bifidum* are less completely known but are apparently smaller, measuring 40–50 μ in diameter. *Telangiopsis arkansanum* is clearly distinct from the above species with respect to synangial dimensions and a slightly larger spore diameter. *Telangiopsis arkansanum* is similar to *T. affine* in having a relatively small number of sporangia in the synangia (approximately six). Our material differs from the above species in that the synangia are borne terminally on a monopodially branched system of axes, whereas the synangia occur in a similar position on an equally dichotomously branched system in both *T. affine* and *T. bifidum*.

Of the remaining compression species, *T. nutans* compares most closely with *T. arkansanum*. *Telangiopsis nutans* is an Upper Carboniferous form occurring in the Westphalian of northern France and Belgium (STOCKMANS and WILLIÈRE 1961). In this species, terminal synangia having four to six sporangia are borne on a monopodially branched system that is believed to form a portion of *Sphenopteris obtusiloba* Brong. The individual sporangia measure about 2–3 mm long and 0.5 mm broad and are fused only in their basalmost regions. The spores of this species are not known. However, the species differs from *T. arkansanum* primarily in the larger dimensions of the synangia.

An additional plant having fertile structures of the "*Telangiopsis* type" borne on the frond is *Diplopteridium teilianum* (Kidston) Walton (WALTON 1931). The fertile structures, which are clearly distinct from those of *T. arkansanum* in that they are larger and have more sporangia per synangium, are borne terminally on the ultimate branchings of an equally dichotomizing system that occurred in the angle produced by a dichotomy of the petiole into two major sterile divisions of the frond. WALTON has suggested that the fertile structures of *T. affine* and *T. bifidum* were borne in a similar position. We lack any definite evidence concerning the relationship of the fertile portions of *T. arkansanum* to the sterile parts. The mode of branching present in *T. arkansanum* is similar to that which occurs in sterile foliage, comparing favorably with *Sphenopteris mississippiana* White, which occurs in abundance at the same locality from which our fertile material has come. As yet, no instance of attachment has been discovered.

As we have noted earlier, difficulties in applying the generic name *Telangium* to compressions, impressions, or encrustations and partial petrifactions

have arisen primarily from two sources. First, it has remained impossible to demonstrate the identity of the petrified form, *T. scotti*, with any of the nonpetrified types. Second, disagreement concerning the basic features present in the nonpetrifaction material has existed from the time of first usage of the generic name *Telangium* by BENSON and has persisted to the present. The two features most in debate are the presence versus absence of the so-called reduced pinnule or limb on which the sporangia are borne, and the unilocular versus bilocular nature of the sporangia. Since the work of KIDSTON on the genus *Crossotheca* Zeiller (KIDSTON 1906), this genus has been characterized by having sporangia borne on the lower surface of a prominent modified pinnule whose shape varies among the various species. In addition, KIDSTON presented illustrations which he used to suggest that each externally separate "sporangium" was in reality bilocular. Most subsequent workers have accepted KIDSTON's interpretations. However, the vast majority of nonpetrified material assigned in the past to both *Telangium* and *Crossotheca* is preserved in such a way as to preclude the determination of the unilocular versus bilocular condition. Furthermore, no author has subsequently reported a bilocular condition in materials of the type in which KIDSTON originally declared it to be present (three-dimensional part-petrifactions occurring in ironstone nodules). In addition, the matter has been confused by the assignment to *Telangium* of specimens in which evidence of a reduced pinnule is present. Thus, in our opinion, the distinctions between the genera may be more imaginary than real. Until such time as a complete reinvestigation of *Crossotheca* is carried out, the generic name should probably be used for any forms in which evidence of a reduced or modified pinnule is clearly present. Those types showing no reduced pinnules and no evidence for bilocular sporangia may then be assigned to *Telangiopsis*. Both *Telangiopsis* and *Crossotheca* should be regarded as form genera.

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